The CALICE Programme
Development of highly granular electromagnetic and hadronic calorimeters for particle flow reconstruction in future collider experiments. Key steps:
- Validation of the concept of high granularity with physics prototypes 🔄
- Technical realization of detector systems satisfying collider constraints - Technological prototypes with fully embedded electronics beam tested.
- Application of CALICE expertise and technology in running experiments e.g. CMS HGCal

A key element: Use of common technologies and infrastructure, e.g. common ASIC family (SKIROC, SPIROC, HARDROC) to facilitate combined running.

Particle Flow Calorimetry
- High sampling frequency and granularity in calorimeters to separate particle showers
- Minimal passive material between tracker and calorimeters
- Calorimeters must be inside the magnet coil
- Requires the design of very compact service electronics and active layers sensitive to the MIP level
- Requires precise mechanical assembly of the calorimeter structure allowing only small tolerances over large areas

Gaseous Readout
GRPC based hadronic calorimeter (SDHCAL): binary and two-bit readout 1 cm^2 pad size
Key developments towards scalability to full size experiments Improved gas flow for new 1x2 m^2 GRPC plates 48-layer technological prototype using GRPC/electronics with steel plates

Digital Silicon ECAL
ALPIDE sensors with ultra-fine granularity (<30x27um) digital pixels sandwiched with tungsten absorber

Silicon Readout
ECAL with tungsten absorber (SiW ECAL):
Silicon pads as active material 9x9 mm^2 wafers with 5.5x5.5 mm^2 cell size
15-layer prototype, fully-embedded triggering electronics

SIPM-on-Tile ECAL
Scintillator tiles + SIPM readout modules to separate particle showers

Beam Tests of Technological Prototypes
Assembly of ~1 m^2 prototypes with fully embedded electronics Rigorous testing of all technologies at TB facilities at CERN/DESY

Achievements
Signal to Noise ratio (S/N) ≈ 12.8 in the SiW ECAL at trigger level:
- Ability to trigger on and read out small signals (MIPS) demonstrated

Digital Silicon Calorimeter

Application of tracking using the Hough Transform technique: Correcting tracks found by the HT improves resolution and assists in electron/hadron discrimination

Successful single cell MIP calibration of the full AHCAL prototype: Good overall detector response. Signal to Noise ratio = MPV_{MIP}/σ_{noise} ≈ 50

Position resolution of better than 2mm in SiW ECAL from cosmic muons

EPICAL-2 shows significant improvements in energy resolution compared to previous digital ECAL prototypes

Implementation of Large Imaging Calorimeters